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UNITED STATES DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
SAN FRANCISCO DIVISION

ATS Automation Tooling Systems, Inc. and Thermal Form & Function, LLC, Plaintiffs, v. Foxconn Electronics, Inc., Foxconn International, Inc., Hon Hai Precision Industry Co. Ltd., and DOES 1 through 10, Defendants.	**Case No. 03-2648 PJH** **DECLARATION OF DR. ROBERT J. MOFFAT IN SUPPORT OF PLAINTIFFS' OPENING CLAIM CONSTRUCTION BRIEF**

I, Dr. Robert J. Moffat, declare as follows:

I. INTRODUCTION

1. I have been retained by ATS Automation Tooling Systems, Inc. and Thermal Form & Function, LLC to provide expert opinions and testimony in the above-captioned case. In particular, I have been asked in this Declaration to explain the principles of heat transfer and heat sink technology, and to comment on the meaning of certain terms in the claims and specification of United States Patent 5,494,098 (the "'098 patent") from the standpoint of one of ordinary skill in the art.

II. BACKGROUND

2. I hold the following degrees: B.S. in Mechanical Engineering from the University of Michigan, specializing in gas turbines (1952); M.S. from Wayne State University in Engineering Mechanics (1961); M.S. and Engineer degrees from Stanford University in Mechanical Engineering (1966); Ph.D. in Mechanical Engineering from Stanford University, specializing in heat transfer (1967).

3. From 1952 to 1962, I was employed as a Senior Research Engineer in the General Motors Research Laboratory in Warren, Michigan. While employed there, I worked on heat transfer problems in automotive engines, aircraft gas turbines, automotive radiators, and gas turbine regenerators. My area of particular specialization was temperature measurements and heat transfer, including the design, testing, and development of heat exchangers.

4. From 1962 to 1967, I was a Research Assistant in the Doctoral program at Stanford University. I joined the faculty of the Engineering Department at Stanford in 1967. From then until 1993, I taught a variety of undergraduate and graduate classes, including thermodynamics, heat transfer, experimental methods, fluid mechanics, radiation heat transfer, convective heat transfer, heat exchanger design, and electronics cooling.

5. Throughout this time, I also engaged in numerous research projects such as

ongoing research to measure heat transfer coefficients in electronics cooling enclosures and a research program on the function and behavior of finned heat sinks.

6. I have authored or co-authored more than 200 publications on the subjects of heat transfer and experimental measurements.

7. I have the honor of being a Fellow of the American Society of Mechanical Engineers ("ASME") and also a Fellow of the Instrument Society of America ("ISA"). I have received numerous awards from these societies, including:

ASME:	Heat Transfer Memorial Award, 1989 Melville Medal for best original research in 1986 Holley Medal for engineering in the service of mankind, 1986 Heat Transfer Division Award for Best Paper of the Year, 1979
ISA:	Robert Abernethy Award, 1989 Mills Dean Award, 1985 Donald P. Eckman Award, 1977

8. Over the years, I have consulted with many of the well-known computer companies on the subject of cooling electronic components. I continue to provide such consulting services.

9. I have not served as an expert witness in any other case in the past five years.

10. I am being compensated at an hourly rate of $375.00 for services at depositions and court appearances, and at an hourly rate of $187.50 for other services. My compensation is not contingent on the outcome of this litigation.

III. DOCUMENTS CONSIDERED

11. In forming my opinions in this case, I have considered the following documents and information:

- Amended Complaint, Case C03-2648PVT: ATS Automation Tooling Systems, Inc., et al. vs. Foxconn Electronics, Inc., et al.

- The '098 patent
- The file history of the '098 patent
- Research Disclosure Reference No. 333100
- U.S. Patent No. 4,790,373 issued to Raynor et al. ("Raynor")
- U.S. Patent No. 4,513,812 issued to Papst et al. ("Papst")

IV. BACKGROUND OF THE INVENTION

12. An active component, such as a microprocessor in a computer or other electronic system, dissipates electrical power. The electrical power dissipated appears as thermal energy within the component, which in turn raises the temperature of the component. If the component temperature exceeds some limiting temperature (usually taken to be around 100°C, the temperature of boiling water), the component may cease to function. This problem is exacerbated as electronic devices, particularly microprocessors, are made smaller and are designed to operate at increasingly higher processing speeds. As a consequence, it is critical, in designing electronic components, to ensure that there is a mechanism to cool the component, i.e., to remove the dissipated energy from the component without allowing the component to reach its limiting temperature. The art and science of electronics cooling has advanced a great deal over the past 25 years. Modern cooling methods employ some very sophisticated methods.

13. The problem posed by the generation of thermal energy in electronics components can be illustrated by one equation: $T_{component}=T_{cool} + Q/hA$. In this equation, "$T_{component}$" represents the temperature of the component (e.g., a microprocessor); "T_{cool}" represents the temperature of the coolant (e.g., air); "Q" represents the rate of heat extraction from the component in watts (equal to the electrical power dissipated within the component); "h" represents the overall heat transfer coefficient (watts per unit area per unit temperature

difference); and "A" represents the effective area available to transfer heat from the component to the coolant.

14. Neither the component nor the coolant is uniform in temperature, and there is no single temperature that characterizes either one. By convention, engineers ignore this subtlety in conversation and in writing, and speak of the appropriate average as the temperature. The methodology used to effect solutions to this problem accounts for this idealization. The definitions of the heat transfer coefficient and the coolant temperature, as used in the actual design equations, are chosen so that the equation shown above works accurately enough to satisfy current technical needs.

15. Taking this equation as the model, then, several options exist to reduce the component temperature, $T_{component}$:

- Reduce the coolant temperature, T_{cool}
- Reduce the power dissipation, Q
- Increase the heat transfer coefficient, h
- Increase the area, A

16. The term "heat sink" refers generally to any device attached to a component that provides an increased area A, thereby allowing the component to operate at a lower temperature without refrigerating the coolant, reducing the power, or increasing the heat transfer coefficient, h.

17. Early heat sinks were made simply of plates of aluminum of a larger size than the component. Attaching the component to the plate allowed its heat to spread through the plate by conduction, and to be dissipated through the surface area of the plate.

18. As component power increased, however, these traditional heat sinks failed to

provide sufficient cooling capacity. As such, it became necessary to add fins to the plate, to increase the effective area. Fins are projections that provide additional area through which heat may be transferred. But the fin area is only effective if coolant flows over the entire area. There are engineering equations for calculating the "effective area" of a fin, depending on its geometry, the material it is made of, and the average heat transfer coefficient.

19. A heat sink with many closely spaced fins appears to have a lot of surface area over which the coolant – typically air – may flow, but that appearance can be misleading. If a heat sink with a "dense" array of fins is used in a system cooled by a centrally located fan or blower (as most systems are), the cooling air will bypass the heat sink, i.e., go around it rather than through it, or enter the front face and escape out the top. This is especially likely to happen if the fins are not "shrouded", i.e., covered at the top. This bypass problem arises because the resistance to air flow through the fin array is higher than the resistance of the alternate path for the air - going around or over the heat sink. Air takes the path of least resistance.

20. Some prior art heat sinks sought to improve air flow across the fins by placing a fan in the proximity of or directly on the heat sink fins. (Heat sinks with fans are often called fan-driven heat sinks.) These prior art heat sinks did not solve the bypass problem and failed to develop sufficient air flow along the fins of the heat sinks. In addition, some prior art heat sinks that removed some fins to create a space for a fan suffered reduced cooling efficiencies due to loss of fin area.

21. The invention claimed in the '098 patent represents an improvement in heat sink technology over the prior art and its products by addressing the bypass and other problems. The invention achieves its beneficial thermal results by using a housing and attaching a fan to the heat sink in such a way that it forces cooling air to pass over all of the area of the fins. The fan

is attached to the housing at the top of the fin array, and directs the air downward towards the base of the heat sink. The air flow divides into two streams, one flowing out through each end of the fin array. The presence of the housing thus limits the direction of the air flow, ensuring that there is increased air flow over the fin area. The result is an inexpensive, fan-driven heat sink that efficiently dissipates heat from electronic devices.

V. OPINION

A. Ordinary Skill In The Art

22. I understand that for purposes of construing the disputed claim terms, it is necessary to examine those terms from the viewpoint of a person of ordinary skill in the art at the time of the invention.

23. In my opinion, the relevant art is the field of heat transfer, particularly the behavior of fin arrays, and, most particularly, electronics cooling and the use of finned heat sinks in electronics cooling.

24. One of ordinary skill in the art in 1994 would be an individual who has a Bachelor of Science degree in Mechanical or Chemical Engineering with some course work in heat transfer or transport mechanisms and two or more years of experience in electronics cooling; or, alternatively, a person with 5 or more years of practical and laboratory experience with at least some coursework in related areas (e.g., thermodynamics, heat transfer, and fluid mechanics).

B. Disputed Claim Terms

25. I understand that the parties have identified the following claim terms as being in dispute: "housing," "extending," "extend(s)," "fins," "channels," and "plenum chamber."

i. "Housing"

26. In my opinion, one skilled in the art would understand the term "housing" to mean "an enclosure." In the present instance, the "housing" encloses and surrounds the fins, but

has openings on its top wall for the fan and at each end of the fin array, so that the fan-driven air can leave the fin array. The housing has side walls and a top wall that, together, cause air that comes out of the fan to flow through the passages between the fins, which limit the escape of air either from the sides or the top of the array. A housing does not need to be impermeable; in fact, as already mentioned, the housing described in the claims of the '098 patent has openings in its top wall for the fan, and in each end-wall for air to leave. The term "housing" does not need to have all the attributes of a box.

27. It is my understanding that the defendants wish to construe "housing" as an enclosure placed over the fins of a heat sink. It is my opinion that this construction is erroneous because not all housings are placed over fins in heat sinks. Moreover, there appears to be no requirement in the claims or the specification of the '098 patent concerning the positioning of the housing relative to any fins of the claimed heat sinks.

ii. "Extending"/"Extends"

28. In my opinion, one skilled in the art would understand the terms "extending" and "extends" to mean "projecting in a direction" and "projects in a direction," respectively. Specifically, I do not think those words imply any "touching" at both ends. From an engineering standpoint, it is difficult to mass produce pieces that fit together perfectly every time, and at the same time, keep manufacturing costs down. Even the most precisely manufactured parts (for example, the gears in a wristwatch) need to have tolerances. Heat sinks are sold in an extremely competitive market; the difference between the quotes of two vendors for the same design may be only pennies. The key to reduced costs is increased manufacturing tolerance. Generally speaking, the less expensive the part, the more generous the tolerance must be to eliminate rejected parts (provided that the increased tolerance must not defeat the purpose of the device).

29. In light of the importance of manufacturing tolerances, if one were to insist on

fins that "touched" the top wall, the function of the array could be seriously compromised. If the inventor had specified the dimensions of the fins to ensure that the average fin actually touched the top wall, as defendants' interpretation suggests, then about half of the fins would interfere with the top wall, and half would not quite reach it. The fins that did not quite reach the top wall would function normally, but those that interfered might buckle and distort the flow channel. This could result in a serious degradation of the performance of the heat sink. One of ordinary skill would understand the claims and specification to mean that none of the fins of the invention need actually to touch the top wall.

30. One objective of the invention of the '098 patent is to ensure that a high percentage of the air flow from the fan passes through the fin-channels. A person of ordinary skill in the art would recognize that the words "extending" and "extends" in the claims of the '098 patent mean that the fins should come as close to the top wall as is reasonable from a manufacturing cost standpoint, but that it is not necessary for the fins actually to touch the top wall. Any gap between the fins and the top wall that is small relative to the flow area would be trivial or insignificant and would not affect the functioning of the heat sink.

31. Furthermore, construing "extend" to mean touching an endpoint is inconsistent with the use of that term elsewhere in the specification. For example, with respect to the rotating blades of the fan assembly, the specification states a plurality of fan blades "extend radially from the rotor within the bore 38." Patent col. 3:30-32. If the defendants' construction were to be applied, it would mean that the fan blades must reach or contact the edge of the bore. However, the fan blades cannot reach or contact anything because that would interfere with the rotation of the fan blades.

32. I have reviewed the file history of the '098 patent. Based on my review of that

document, it is my understanding that the applicant of the '098 patent sought to distinguish his invention from those in which the fan was "substantially spaced" from the fins, and in particular the Raynor patent (U.S. Patent No. 4,790,373). Based on my reading of the '098 patent file history and the Raynor patent, the phrase "substantially spaced" refers to a gap that would have a significant effect on the flow and the heat transfer characteristics of the fin array.

33. From my own experience, and believing the inventor to be at least of ordinary skill in the art, I do not believe the claim terms in the patent can fairly be read to restrict the invention to one in which the fins must touch the top wall. Indeed, nowhere does the specification make such a statement or imply such a requirement. Thus, the applicant's statements in the file history do not mean that it is necessary for the fins to touch the top wall to be within the scope of the invention.

iii. "Fins"

34. In my opinion, one skilled in the art would understand the term "fins" to mean "projections for increasing heat transfer from an object." There are many examples of fins of many shapes and sizes including, e.g., pin fins, wire fins, corrugated fins, wavy fins, lanced fins, and offset fins. The common feature of all of these types of fins is that they are projections from the surface of the heat sink that increase the effective area available to transfer heat.

35. I understand that the defendants contend that the term "fin" refers to a "flattened projection" for heat transfer from an object. This interpretation is incorrect, in my view, because it is unduly restrictive and does not represent the engineering usage of the word "fin" during the past 50 years. Also, to the extent that the defendants' interpretation suggests a mechanical process of "flattening," there is nothing in the literature that requires such a process for all "fins". Similarly, based on my review of the '098 patent specification, there is nothing in the specification that mandates such a process for the claimed "fins".

iv. *"Channels"*

36. In my opinion, one skilled in the art would understand the term "channels" to mean "passages for air flow." For example, the space between two adjacent fins in the array defines a "channel" for air flow even in the portions of the array where the tops of the fins have been cut away to permit the fan air to enter.

37. I understand that the defendants contend the term "channel" means an enclosed passage through which air moves. In my opinion, the defendants' interpretation is incorrect, because not all portions of all channels described in the '098 patent are enclosed. For instance, the '098 patent specification describes (col. 3, l. 16-18) one embodiment in which the portions of the tops of the fins beneath the fan aperture are severed. The space between any two severed fins constitutes a channel through which the air may flow, just as much as the space between any two unsevered fins. Moreover, the claims themselves make clear that the channels are not enclosed, but instead are open at either end. Therefore, the invention of the '098 patent is not limited to "channels" that are "enclosed".

38. I am aware that, during the prosecution of the '098 patent, in distinguishing the Raynor patent, the applicant stated that the Raynor patent "represents a teaching away . . . from the teachings of applicant's heat sink assembly wherein the fan is outside of the confines of the fins to provide a perpendicular air flow from the fan to the fins, while maintaining the channels between the fins enclosed except for the end openings. Applicant's heat sink assembly retains the advantages of Pabst et al. with respect to the enclosed channels to provide maximum airflow between the fins without the disadvantages of the reduction of fin surface area due to the area which must be provided for the fan." These comments were made in the context of the applicant's statement about Raynor, where the fan was located approximately six inches from the fins. In other words, in Raynor, there was a significant space between the fins and fan, such that

air could freely escape from the channels defined by the fins, an adverse result that was avoided by the claimed invention. The applicant accordingly referred to Raynor's channels as being "unrestricted."

39. In the '098 patent, one objective was to ensure that the air flows directly into the channels created by the fins. As I noted previously, and as the applicant himself recognized, a gap between the fan and the fins that is more than "trivial or insignificant" would prevent the claimed device from performing the function for which it was designed. If the applicant considered any portion of his channels to be "enclosed," it was only in the sense that there was no large (e.g., approximately six inch) spacing between the fan and the fins. "Trivial or insignificant" spacing between the fan and the fins would have no measurable effect on the performance of the heat sink. There is nothing in the claims of the '098 patent, the patent specification, or the file history that **requires** the channels to be sealed in any way. The channels of the claimed invention need not be sealed in order for the invention to perform as intended. This is why the word "enclosed" does not appear in the claims as a modifier of "channels".

v. "Plenum Chamber"

40. It is my opinion that one of ordinary skill in the art would understand the term "plenum chamber" to mean "a space for distribution of air."

41. I understand that the defendants contend that a "plenum chamber" refers to an enclosed space in which air is at a pressure greater than that of the outside atmosphere. I find this definition to be inconsistent with engineering usage of that word over the past 50 years or more. A plenum chamber is generally an enlargement of the flow channel made with the intent of improving flow uniformity. Under some conditions, this results in the pressure in the plenum being greater than in the channel approaching the plenum (a consequence of Bernoulli's equation). However, that phenomenon is a consequence of the enlarged flow area, not the

defining feature of a plenum. The pressure inside the plenum chamber of a heat sink, like that described in the '098 patent, could be lower than the air outside the chamber if the direction of the air flow were reversed (i.e., if the fan were installed upside down). Consequently, the pressure of the air within the plenum chamber is not necessarily greater than that of the outside atmosphere. Accordingly, one skilled in the art would understand the term "plenum chamber" to simply mean a space for distribution of air, without regard to the pressure of the air in the plenum chamber relative to air in the atmosphere.

VI. CONCLUSION

42. As this case is ongoing, I may supplement the opinions herein at a later date based upon further information provided to me.

I declare under penalty of perjury that the above is true and correct.

Executed this 11th day of May, 2004 in San Antonio, Texas

Robert J. Moffat

Dr. Robert J. Moffat